INDOOR AIR QUALITY ASSESSMENT

Sumner Avenue Elementary School
45 Sumner Avenue
Springfield, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Judy Dean, Western Massachusetts American Lung Association, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA), was asked to provide assistance and consultation regarding indoor air quality at the Sumner Avenue Elementary School (SAES), 45 Sumner Avenue, Springfield, Massachusetts. Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA visited the school on June 16, 2002 and July 26, 2002 to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Michael Foley of the SAES and Ms. Dean during the July visits. Mr. Feeney returned the SAES on November 8, 2002 to conduct follow up evaluation and air monitoring. Reports of inadequate ventilation, odors, lack of temperature control and other indoor air quality issues prompted the assessment.

The school consists of two separate buildings: the original building and the annex. The SAES is a two-story, red brick building, consisting of two classroom wings. The original wing (see cover) was a freestanding school building constructed 1910s-1920s era. The original building was renovated in 1998 when the new wing was added to the rear of the building. The original building consists of two stories and a finished basement. A crawlspace attic exists between the roof and ceiling of the second floor. The boiler room is located in the basement of this wing. It appears that the building originally possessed a gravity type of ventilation system. The renovation included the installation of a mechanical heating and cooling ventilation system; a new roof; and refurbished classrooms. A new, two-story wing was attached to the rear of the original building. A large atrium with stairwells connects the various floors in both wings. A mechanical smoke ejector ventilation system was installed within the atrium. The new wing contains classrooms. The first floor contains the cafeteria and the second floor contains the gymnasium. A two story mechanical room exists adjacent to the gymnasium. Windows are openable in classrooms.

An annex building exists to the west of the main school buildings that is a two room, single story structure, built as a commercial building, possibly during the 1930s. The annex is the subject of a separate report.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school complex houses kindergarten through fifth grades with a student population of approximately 350 and a staff of approximately 30. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from the table that carbon dioxide levels were above 800 parts per million parts of air [ppm] in three of eight areas surveyed, indicating inadequate fresh air exchange in these areas.

Fresh air in the SAES is provided by rooftop air handling units (AHUs) (see Picture 1). The AHUs provide fresh air via wall mounted fresh air diffusers connected to variable air ventilation (VAV) boxes via ductwork. Air is returned to the AHU by wall mounted exhaust vents. Each VAV box has a set of control dampers that open or close depending on the temperature demand for a serviced area. Once the thermostat detects that the temperature has reached a predetermined level, the VAV box damper closes until heating or cooling is needed. VAV boxes also control the provision of fresh air to a serviced space. Therefore, during times that the temperature of a space is adequate, the VAV box closes its damper, and limits the amount of fresh air. A thermostat controls the operation of the VAV boxes. If the thermostat and/or dampers themselves are malfunctioning or not balanced, the operation of the VAV box may not operate in a manner to provide fresh, conditioned air. If the thermostat calls for the HVAC system to provide heat, the AHU fresh air intake damper would shut to increase the temperature of the air in the ductwork and occupied spaces. Therefore, airflow would be noted from the ceiling air diffusers because the VAV box dampers are open, but fresh air supply would be limited by the closing of the rooftop fresh air intake damper. While it has the advantage of energy conservation and lower operating costs, VAV box systems may cause problems of insufficient outside airflow. For example, once the temperature requirement is met, airflow drops. Airflow can drop to zero in poorly performing HVAC systems (Plog, Niland and Quinlan, 1996).

Heating and cooling is supplemented by a fan coil unit (FCU) (see Picture 2). Each FCU is located on exterior walls underneath windows. The FCUs are incapable of introducing fresh outdoor air. The FCU draws air from the room through a filter in the base of the cabinet into fans. Fans force air through coils that either heat or chill the air. Conditioned air exits the FCU through fixed louvers on the top of the cabinet. Fan coil units (FCUs) located at the base of windows provide heating or cooling as needed for each room. These units do not introduce outside air but recirculate and temper air *only*.

Other supplemental ventilation systems specific to certain areas were also identified. Two AHUs were found in the original wing attic. These AHUs provide fresh air to teacher rooms on the second floor. The kitchen has a gas-fired make up air vent (see Picture 3). The kitchen also has a large kitchen hood for the purpose of ejecting cooking/stove products of combustion from the building. The gymnasium has a separate ventilation system. Fresh air is provided by diffusers installed on ceiling-hung ducts (see Picture 4). The gymnasium also has ceiling fans.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was most likely done after the renovation/construction project of 1998. No documentation concerning balancing was available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature readings (ranging from 70^{o} F to 71^{o} F) were within the BEHA recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measurements ranged from 50 to 56 percent, which were also within the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The HVAC system has the capacity to provide air conditioning during warm weather. Each AHU and FCU has pan/condensation drain system installed. When warm, moist air passes over a surface that is colder than the air water condensation can collect on the cold surface. Over time, water droplets can form, which can then drip from a suspended surface. For this reason, HVAC systems are equipped with drainage systems beneath cooling coils to drain condensate as moist outdoor air is cooled. Selected FCU drip pans were examined. All were found to be partially level, resulting in accumulation of water. Drip pans need to be beveled towards the drain in order to readily drain accumulated water. In room 221, a musty odor was detected. The drip pan in one of the FCUs was found to have an active mold colony (see Picture 5). BEHA staff poured approximately 12 fluid ounces of water into a univent drip pan to observe the rate of drainage. Most of this water appeared to pool in the drip pan with minimal drainage. In every univent examined, a characteristic pattern of accumulation of debris was noted, indicating that water accumulates within each pan (see Picture 6).

Of note was the condition of the casing of the FCUs. Instead of installing univents as a complete metal case as in the old wing it appears that the internal workings of a FCU were encased in specially designed wooden cabinets (see Picture 7) in the new wing. FCUs in the new wing appear to have a pattern of mold colonization of the wooden cover on the surface in contact with moving air created by the FCU (see Picture 8). In the air-chilling mode, the walls and drip pan of the FCU are reduced, which may produce condensation. Chilled air also reduces the temperature of the sidewalls of the univent air-handling chamber, subsequently resulting in condensation generation inside the control and utility chambers. In order to avoid the generation of moisture, the underside of drip pans and the exterior walls of the univent air-handling chamber are usually insulated. No FCU examined had insulation installed on surfaces in contact with chilled air, which may result in mold growth.

FCU condensation pans on the first floor in new wing and the ground floor in the old wing empty into a condensation pump (see Picture 9). The pump is connected to a pipe system that drains water away. Each pump should activate once water accumulates within the base of the unit. Five pumps were randomly selected and tested by the introduction of over 8 ounces of water into each device through the condensation drain. Four pumps failed to activate. One pump activated for approximately 10 seconds, then deactivated. All pumps failed to remove the majority of water collected within the pump water collector. This condition would result in water accumulating and pooling in the base of each pump. Condensation collectors in the pumps were heavily coated with debris that would serve as growth medium for microbial growth. Without drainage, it would be expected that these condensation pumps would remain filled with water for several days or weeks. Under this condition, each pump could potentially serve as a source of mold contamination.

The atrium contains an interior garden with living plants (see Picture 10). Plants can be a source of pollen and mold, which can be a respiratory irritant to some individuals. Plants should be properly maintained and have adequate drainage.

The attic of the original wing has a number of passive air vents (see Picture 11). Of note was the accumulation of bird nesting materials and wastes observed inside two of the passive vents with damaged or missing bird screens. Bird wastes in a building raise concerns over diseases that may be caused by exposure to bird wastes. These conditions warrant clean up of bird waste and appropriate disinfection. Certain molds (*Histoplasma capsulatum)* are associated with bird waste (CDC, 2001; NIOSH, 1997) and are of concern for immune compromised individuals. Diseases of the respiratory tract may also result from exposure to bird waste. Exposure to bird wastes is thought to be associated with the development of hypersensitivity pneumonitis in some individuals. Psittacosis (bird fancier's disease) is another condition closely associated with exposure to bird wastes in bird raising and other occupational settings. While immune compromised individuals have an increased risk of health impacts following exposure to the materials in bird wastes, these impacts may also occur in healthy individuals exposed to these materials.

The methods to be employed in clean up of a bird waste problem depends on the amount of waste and the types of materials contaminated. The MDPH has been involved in several indoor air investigations where bird waste has accumulated within ventilation ductwork. Accumulation of bird wastes have required clean up of such buildings by a professional cleaning contractor. In less severe cases, the cleaning of the contaminated material with a solution of sodium hypochlorite has been an effective disinfectant (CDC, 1998). Disinfection of non-porous materials can be readily accomplished with this material. Porous materials contaminated with bird waste should be examined by a professional restoration contractor to determine if the material is salvageable. Where a porous material has been colonized with mold, it is recommended that the material be discarded (ACGIH, 1989).

The protection of both the cleaner and other occupants present in the building must be considered as part of the overall remedial plan. Where cleaning solutions are to be used, the "cleaner" is required to be trained in the use of personal protective methods and equipment (to prevent either the spread of disease from the bird wastes and/or exposure to cleaning chemicals). In addition, the method used to clean up bird waste may result in the aerosolization of particulates that can spread to occupied areas via openings (doors, etc.) or by the ventilation system. Methods to prevent the spread of bird waste particulates to occupied areas or into ventilation ducts must be employed. In these instances, the result can be similar to the spread of renovation-generated dusts and odors in occupied areas. To prevent this, the cleaner should employ the methods listed in the SMACNA Guidelines for Containment of Renovation in Occupied Buildings (SMACNA, 1995).

Shrubbery exists in close proximity to the foundation walls (see Picture 12). The growth of roots against the exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek, J. & Brennan, T.; 2001).

Other Concerns

Dust Accumulation

Of note was an accumulation of dust within the building, particularly within the hallways and gymnasium (see Pictures 13 and 14). As a result of building occupants concern about indoor air quality, the Springfield School Department commissioned a dust sampling study at the SAES (ATC, 2002). This study produced airborne dust sampling results that were below the outdoor air quality standards. The US Environmental Protection Agency has established National Ambient Air Quality Standards (NAAQS) for exposure to total particulate with a particle diameter of $\leq$ 10 micrometer (e.g., PM 10) in outdoor air . PM 10 levels in outdoor air must be maintained at a concentration below 75 micrograms (μg)/cubic meter of air over a twenty-four hour period in order to meet this standard (US EPA, 2000). In evaluating indoor air quality, concentrations of materials that are subject to NAAQS should not be exceeded indoors (BOCA, 1993; ASHRAE, 1989). This air monitoring did not indicate that the PM10 exceeded the NAAQS. A bulk sample of dust taken from the gymnasium indicated that the accumulation dust consisted of: cellulose fibers 50%; synthetic fibers 25%; skin flakes 10%; human hairs 5%; and miscellaneous materials 10% (P & K Microbiology Services, Inc., 2002). In an effort to identify the potential source of this dust, various building structures were examined as possible sources of this dust. The attic of the original wing; mechanical rooms; interiors of various FCUs; area above the suspended ceiling in the second floor hallway; interior of rooftop and mechanical AHUs and the boiler room were examined. None of these areas appeared to have possible sources of the accumulated dust within the building. Without indoor sources of cellulose particles, several means for unfiltered outdoor air to enter the building were examined. Of note are several structures located on the roof: the make up air vent for the kitchen (see Picture 3); passive air vents in the ceiling of the gymnasium (see Picture 15); air intakes for the emergency smoke ejector system (SES) (see Picture 16); and the exhaust vent for the emergency smoke ejector system (see Picture 17). The purpose of the make up air vent is to provide sufficient air to allow for the kitchen exhaust vent hood to draw air efficiently. In the case of a fire, the purpose of the SES is to rapidly remove smoke from the hallway and atrium of the building. Each of these units has several characteristics that may provide a pathway for unfiltered air to enter the building.

- None of the mechanical units were/are activated on a day-to-day basis.
- The ceiling vents of the gymnasium appear to be open to the <u>*outdoors*</u> .

•The make up air vent for the kitchen has no means to insert filters to remove particles from its air stream.

•The SES exhaust vent and stack do not have a backdraft damper on the top of the stack (see Picture 17) nor in the ductwork (HMFH; 1997; see Blueprint 1).

The operation of the make up air vent can result in unfiltered air and particles entering the building. The gymnasium ceiling passive vents and SAES can serve as potential pathways for outdoor particles. Cold outdoor air can sink into the building through inactive ductwork, creating a backdraft that can draw particles into the building.

Cellulose is a common constituent of paper, leaves, wood, and plants. The normal operation of a school building would be expected to have cellulose dust from the use of paper or paper–using machinery.

Of note is the configuration of the gymnasium fresh air supply ducts that may also provide a potential source of particles. Circular fresh air supply vents (HMFH; 1997; see Blueprint 2) were noted to have fresh air diffusers located several feet from the end of each circular duct (see Picture 18). The space at the end of each vent can accumulate debris and serve as a reservoir for particulates that can be distributed by the air diffusers. In addition the gymnasium ducts are likely to be internally lined with insulation. Since the HVAC system provides cooling during warm weather, internal insulation of these ducts would be necessary to prevent the generation of condensation on the exterior surface of the ductwork, which would in turn collect a drip onto the gymnasium floor. Internal lined ductwork may accumulate dust and debris that can be distributed into the interior environment.

Products of Combustion

A second source of pollutants that can be introduced into the building relates to the kitchen. The process of combustion produces airborne liquids, solids and gases, including carbon monoxide (NFPA, 1997). The measurement of carbon monoxide can be used to pinpoint the source of combustion products. During the assessment, measurable levels of carbon monoxide were detected in the new wing. This source of carbon monoxide was traced to the kitchen. The kitchen uses a number of gas-fueled cooking devices (see Picture 19). The products of combustion and cooking odors are designed to be drawn in and subsequently ejected from the building via a large oven hood. The oven hood was deactivated at the time of these carbon monoxide air measurements. After lighting one burner on the top of the stove, carbon monoxide levels measured at the burner level were in a range of 15 parts per million (ppm). Therefore, it is likely the measurable levels of carbon monoxide were attributable to the use of gas-fueled cooking equipment without the oven exhaust vent hood activated. The oven exhaust vent hood was deactivated at the time of the carbon monoxide air sampling. The oven exhaust vent hood has three settings: "high", "low" and "off". After this measurement, BEHA staff recommended that the oven exhaust vent hood be operated in the low setting to provide exhaust ventilation for the gas pilot lights in each gas-fueled cooking device to avoid the accumulation of carbon monoxide in the kitchen and adjacent areas. Another source of carbon monoxide is a heating device installed for the kitchen that is located in the roof. A gas-fired make-up air vent for the kitchen was installed in the roof (HMFH; 1997; see Blueprint 3, Picture 3). This device directly heats fresh air drawn into it with open gas vents. This introduces heated air and gas products of combustion into the kitchen when activated. The process of combustion produces a number of pollutants, depending on the composition of the material. In general, common combustion emissions can include carbon dioxide, CO, water vapor and smoke. Of these constituents, CO can produce immediate, acute health effects upon exposure. The MDPH established a correction action level concerning CO in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a CO level over 30 ppm taken 20 minutes after resurfacing within the rink, that operator must take actions to reduce CO levels (MDPH, 1997).

The US Environmental Protection Agency has established National Ambient Air Quality Standards (NAAQS) for exposure to CO in outdoor air. CO levels in outdoor air must be maintained below 9 ppm over a twenty-four hour period in order to meet this standard. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and BOCA use these NAAQS as measures for assessing indoor air quality in buildings (BOCA, 1993; ASHRAE, 1989). It is recommended that all gas cook tops and ovens be vented to the outdoors to prevent exposure to products of combustion (Lstiburek, J. & Brennan, T.; 2001).

Several conditions exist in the boiler room that may also provide for products of combustion to enter this room. The configuration of the ventilation system in the boiler room may be problematic. A return air vent is located near the front of the boilers (HMFH; 1997; see Blueprint 4). In this configuration, the return vent has the potential to draw air and related pollutants from the boilers when the power vent is deactivated. In order for boilers to combust fuel a sufficient supply of oxygen is necessary. The return vent location may have the following negative effects if the draw of air is greater than the boiler when the power vent is deactivated:

1. The boiler could become deprived of oxygen, creating a fuel rich combustion mixture that increases incomplete combustion products, including carbon monoxide.

2. The products of combustion produced by the boilers can be drawn by the AHU and be distributed into the boiler room instead of the chimney.
3. The AHU can also draw other pollutants, including sewer odor from the sump pump, and distribute them into the boiler room.
4. The decrease in combustion efficiency may lead to increased fuel consumption and increased energy costs.

The purpose of a return air vent in the boiler room is unclear. In this configuration, the return vent should not operate if the boiler is operating. A collection of soot was noticed beneath a horizontal section of boiler exhaust vent duct. An examination found a hole at the bottom of each duct filled with tattered fiberglass insulation. It appears that as the boiler power vents operate, products of combustion are forced into the duct and are exiting the duct through this hole. Exhaust vent pipes should be continuous to prevent this contingency. In addition, the configuration of the exhaust vent ducts tends to restrict the exhaust of air from the boilers. The duct to the chimney connected to the gas water heater is horizontal, approximately 40 feet in length and has an estimated 540^{o} in turns of duct. In general, exhaust ducts should minimize the numbers of horizontal pipes and turns. Increasing length and turns in exhaust ductwork can decrease the efficiency of products of combustion to the chimney. In addition, several extra lengths of duct exist off the main line of exhaust airflow in the ducts. These extra lengths of exhaust vent create dead spaces where products of combustion can accumulate. Under these conditions, products of combustion can pool in the ducts. Water vapor mixing with other products of combustion can create corrosive materials that can degrade the metal of the ductwork. Products of combustion then may enter into occupied areas through spaces beneath the boiler room door as well as other holes that lead to occupied spaces. Operating equipment that draws air from the basement (e.g. the AHU and restroom vents) may enhance the draw of combustion products into occupied areas of the building, which may serve as a source for CO and other products of combustion to be introduced into the SAES indoor environment.

Miscellaneous

A number of other conditions that can potentially affect indoor air quality were also observed. A number of classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999). These VOCs can be irritating to the eyes, nose and throat.

The teacher's workroom contained a lamination machine and photocopier. Lamination machines can produce irritating odors during use. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). School personnel should ensure that local exhaust ventilation is activated while equipment is in use to help reduce excess heat and odors in these areas.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (see Picture 20). Tennis balls are made of a number of materials that can be a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gassing volatile organic compounds (VOCs). Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix II (NIOSH, 1998).

Of note is the use of cleaning materials throughout the building. Cleaning materials frequently contain ammonium compounds or sodium hypochlorite (bleach-products), which are alkaline materials. The use of these products can provide exposure opportunities for individuals to a number of chemicals, which can lead to irritation of the eyes, nose or respiratory tract. In all of these instances, cleaning products containing respiratory and skin irritants appear to be used throughout the building.

Conclusions/Recommendations

The conditions noted at the SAES raise a number of indoor air quality issues. Based on the air tests conducted, visual inspection and reported complaints of occupants, measures should be taken to eliminate/minimize products of combustion within the building. To this end, consider consulting a heating system engineer to examine and advise as to the appropriate measures needed to implement the following recommendations. In view of the conditions found in the SAES at the time of the assessment, the following recommendations are made:

1. Install a wall-mounted CO alarm with digital readout in the boiler room and kitchen. CO levels should be checked daily after the boiler is fired up during the heating season.
2. Repair the controls for the oven exhaust vent hood to allow for it to operate at the low setting.
3. Consider disconnecting and sealing the make up air device for the oven exhaust vent hood. Use the air introduced into the cafeteria as the source of make up air for the oven exhaust vent hood.

4. Consult a boiler engineer concerning methods to seal the holes in the base of the boiler exhaust ducts.
5. To overcome the length and bends (turns) in the exhaust vents for the boilers, the addition of a power fan within the exhaust vent dusts or on top of the chimney should be considered to facilitate removal of pollutants to the outdoors.
6. Examine the purpose of the return air vent in the boiler room. If it is purpose cannot be identified, consideration should be given to sealing this vent to prevent the draw of products of combustion from the boiler.
7. Consult a ventilation engineer to maximize the operation of all AHUs, VAV boxes and FCUs. Increase the amount of fresh air drawn by AHUs to increase comfort. Have the mechanical fresh air supply and exhaust balanced.
8. Clean bird waste in a manner consistent with methods described in the bird waste section.
9. Consideration should be given to rendering the boiler room as airtight as possible to eliminate the draw of combustion air to the occupied areas of the SAES. These measures would include installing weather-stripping along the doorframe and a door sweep at the bottom of the boiler room access door.
10. Clean accumulated mold and debris from the FCU dip pans. Enhance drainage by increasing the pitch of FCU drip pans.
11. Repair or replace all non-functioning FCU condensation pumps. These pumps should be tested every spring prior to activation of the air-conditioning system for function by pouring water into condensation pans and monitoring water removal. The interior collectors for condensation drains should be cleaned before and after the cooling season to prevent the accumulation of mold growth-supporting media.

12. Examine the ends of circular ducts of gymnasium vents for accumulation of debris and clean as needed. Consider opening the end of each circular duct and install a fresh air diffuser to reduce the dead spot in the bullpen and other areas with this condition.
13. Examine the condition of the insulation of the gymnasium duct for debris accumulation/degradation. Consideration should be given to cleaning the interior of this duct if a heavy debris accumulation is noted.
14. Remove foliage to a minimum of five feet away from the foundation.
15. Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek, J. & Brennan, T.; 2001).
16. Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek, J. & Brennan, T.; 2001).
17. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. This dust control method may be used in conjunction with existing cleaning equipment. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
18. Reduce the use of cleaning materials that contain respiratory irritants (ammonia related compounds) on floors and in classrooms. Do not use these materials to disinfect equipment that comes into close contact with the respiratory system (e.g., telephones).

Substitute plain soap and hot water for ammonia related cleaning products. Use of ammonia related cleaning products should only be where necessary. If ammonia-containing cleaning products are used, rinse the area of application with water to remove residue.

19. Have a chemical inventory done in all storage areas and classrooms. Properly store flammable materials in a manner consistent with the local fire code. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Follow proper procedures for storing and securing hazardous materials. Obtain Material Safety Data Sheets (MSDS) for chemicals from manufacturers or suppliers. Maintain these MSDS' and train individuals in the proper use, storage and protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F. (MGL, 1983).
20. Discontinue the use of tennis balls on chairs to prevent latex dust generation.
21. Store cleaning products properly and out of reach of students.
22. Ensure exhaust ventilation is activated in work areas to help reduce lamination machine and photocopier odors.

Long Term Recommendations

1. Identify whether air backdraft dampers are installed in the SES components. If no backdraft dampers exist, consideration should be given to installing these devices.
2. Identify the purpose of the passive vents in the gymnasium ceiling. If open to the outdoors, consider installing a backdraft damper system to prevent unimpeded outdoor airflow into the gymnasium.

References

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

CDC. 2001. Histoplasmosis. CDC Website. Centers for Disease Control and Prevention, National Center for Infectious Diseases, Division of Bacterial and Mycotic Diseases, Atlanta, GA.

http://www.cdc.gov/ncidod/dbmd/diseaseinfo/histoplasmosis_g.htm

CDC. 1998. Compendium of Measures to Control Chlamydia psittaci Infection Among Human (Psittacosis and Pet Birds (Avian Chlamydiosis), 1998. *MMWR 47:RR-10. July 10, 1998.*

HMFH. 1997. Additions and Renovations to Sumner Avenue Elementary School, Springfield, MA blueprints. HMFH Architects, Inc., Cambridge, MA.

Lstiburek, J. & Brennan, T. 2001. Read This Before You Design, Build or Renovate. Building Science Corporation, Westford, MA. U.S. Department of Housing and Urban Development, Region I, Boston, MA

MDPH. 1997. Requirements to Maintain Air Quality in Indoor Skating Rinks (State Sanitary Code, Chapter XI). 105 CMR 675.000. Massachusetts Department of Public Health, Boston, MA.

NIOSH. 1998. Latex Allergy A Prevention. National Institute for Occupational Safety and Health, Atlanta, GA.

NIOSH. 1997. Histoplasmosis: Protecting Workers At Risk. National Institute for Occupational Safety and Health, National Center for Infectious Diseases, Cincinnati, OH. DHHS (NIOSH) Publication. No. 97-146 September 1997.
http://www.cdc.gov/niosh/97-146.html

NIOSH. 1997. NIOSH Alert Preventing Allergic Reactions to Natural Rubber latex in the Workplace. National Institute for Occupational Safety and Health, Atlanta, GA.

Plog, Barbara, Niland, Jill and Quinlan, Patricia, eds. *Fundamentals of Industrial Hygiene*. 4th ed. Illinois: National Safety Council, 1996.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBAA. 2001. Latex In the Home And Community Updated Spring 2001. Spina Bifida Association of America, Washington, DC.
Http://www.sbaa.org/html/sbaa_mlatex.html

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, D.C. EPA 402-K-01-001. March 2001.
http://www.epa.gov/iaq/molds/mold_remediation.html

US EPA. 2000. National Ambient Air Standards (NAAQS). . US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

Picture 1

Rooftop AHUs

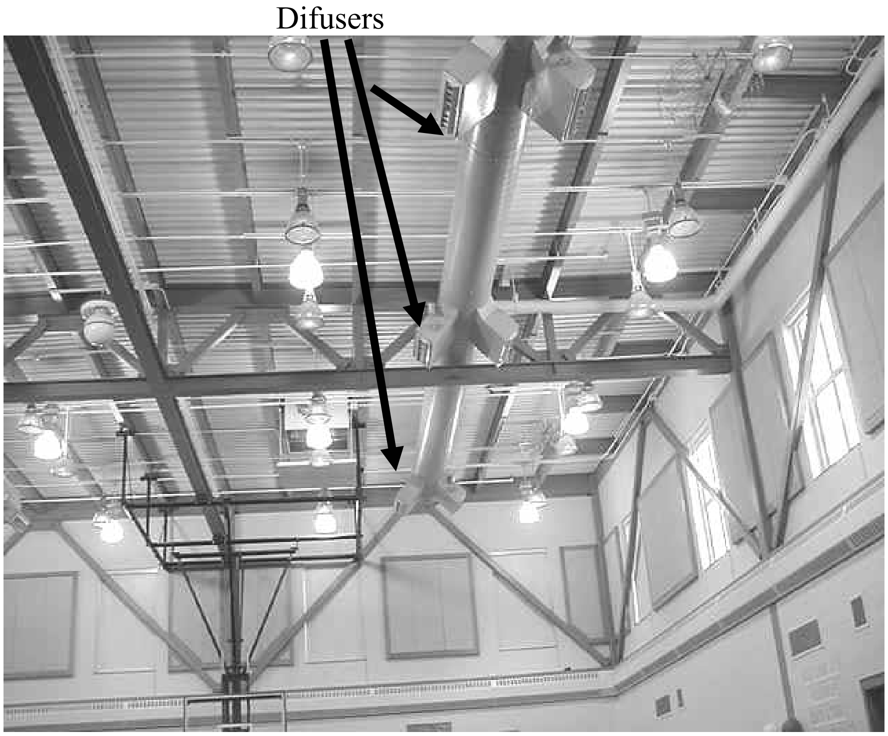
Picture 2

FCU in New Wing

Picture 3

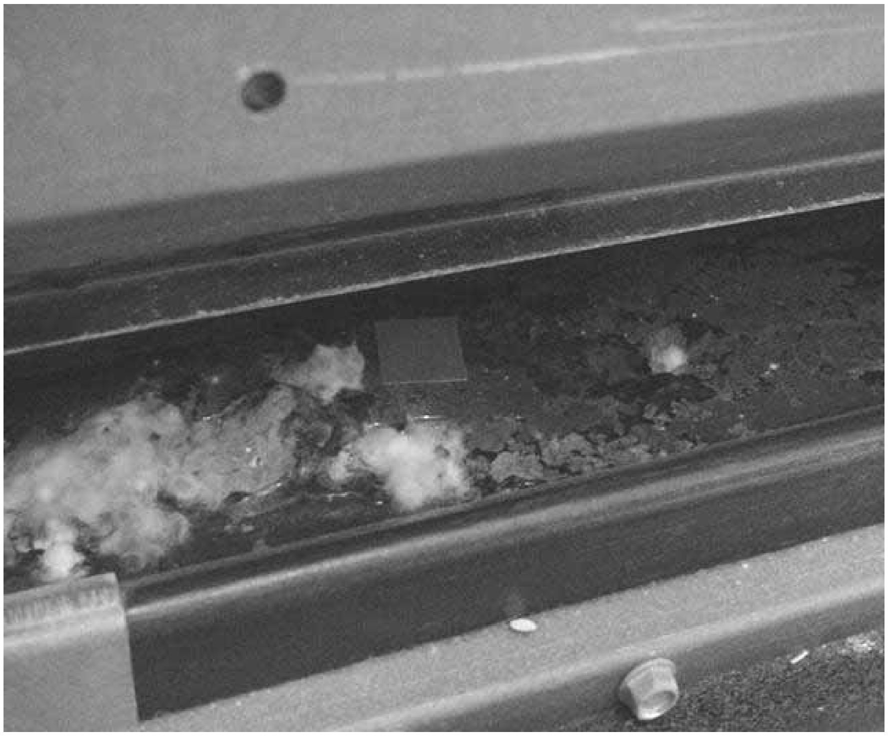
Rooftop kitchen Gas-Fired Make Up Air Vent

Picture 4



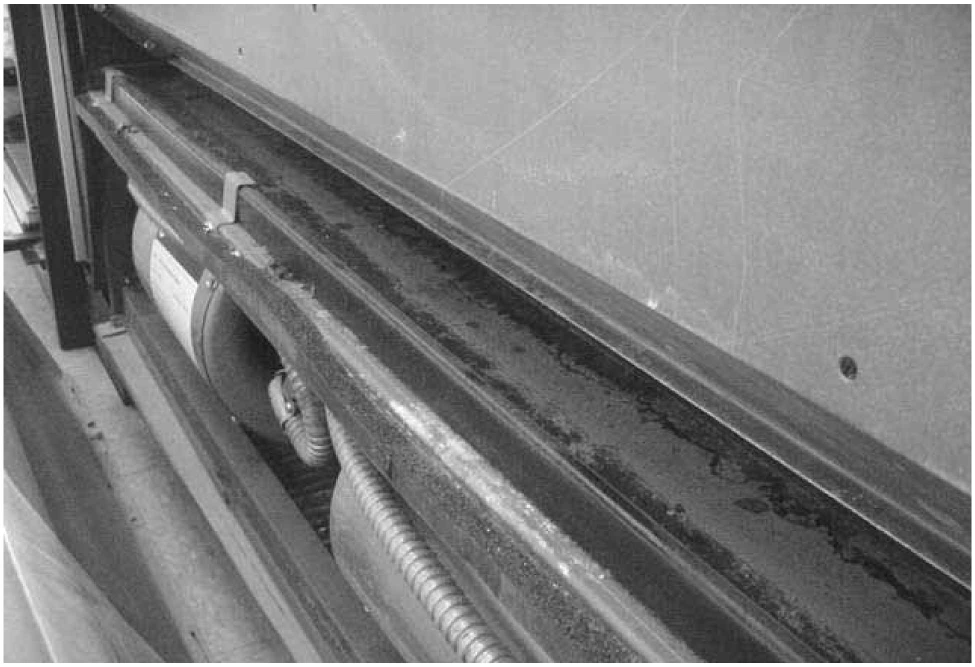
Gymnasium Ductwork and Fresh Air Diffusers

Picture 5



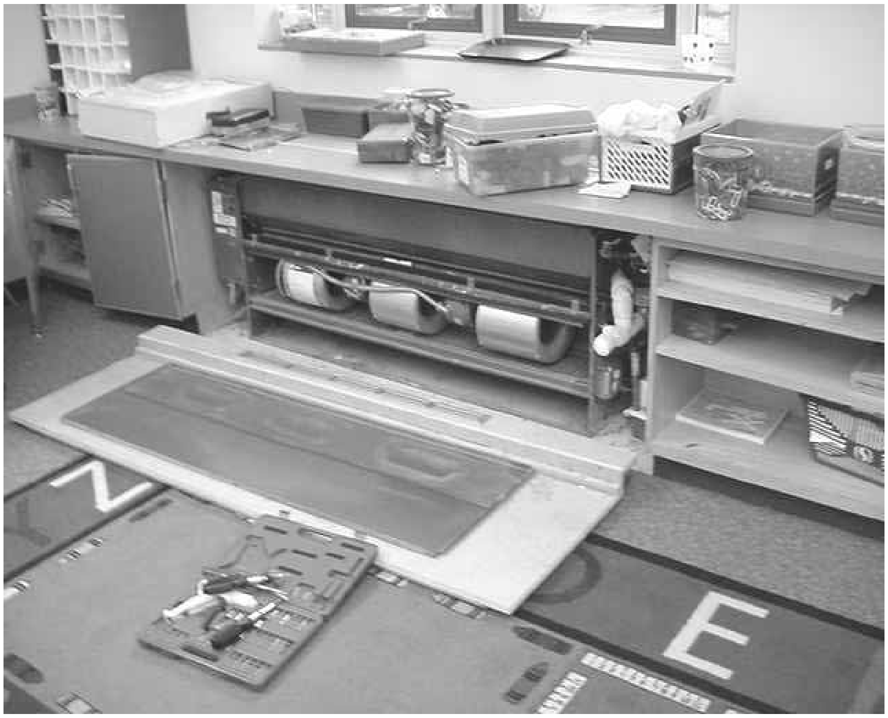
Mold Colony in FCU Drip Pan in Room 221

Picture 6



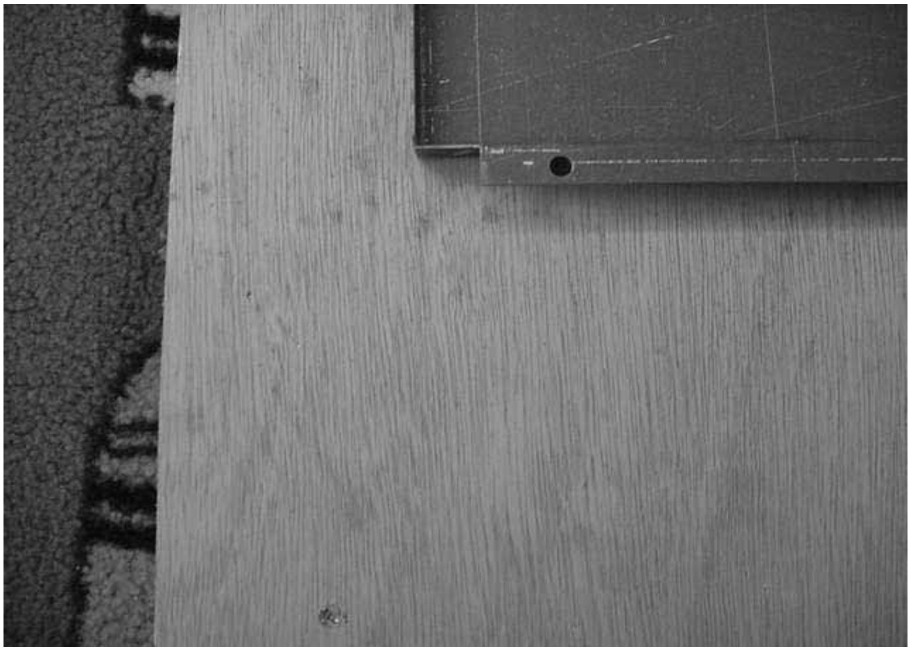
Accumulated Debris in FCU Drip Pan

Picture 7



New Wing FCU Were Encased in Specially Designed Wooden Cabinets

Picture 8



Wooden Cover of New Wing FCU, Note Subtle Spotting That May Indicate Mold Colonization

Picture 9

FCU Condensation Pump

Picture 10

Plants in atrium

Picture 11

Passive Attic Vent

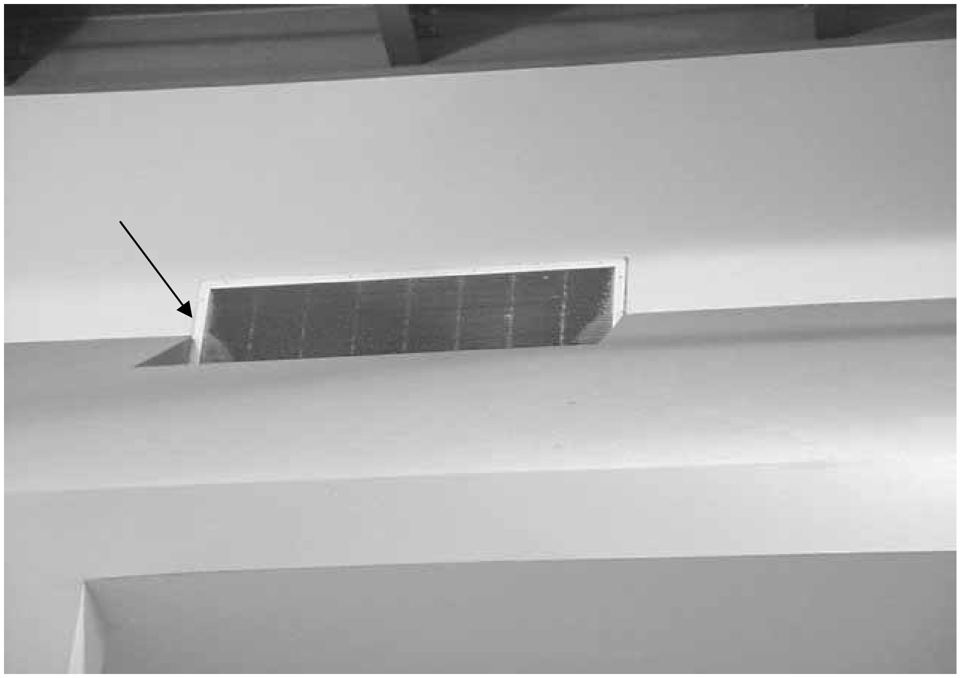
Picture 12

Shrubbery in Close Proximity to Old Wing's Exterior Wall

Picture 13

Dust Accumulation on Cabinet in Hallway

Picture 14



Dust Accumulation on Slopes Wall in Gymnasium, Note Accumulation of Dust on Return Vent

Picture 15

Gymnasium Passive Air Vents

Picture 16

Fresh Air Intakes for SES

Picture 17

Exhaust Vent for the Emergency Smoke Ejector System

Picture 18

Fresh Air Diffusers Located Several Feet from the End of Each Circular Vent in Gymnasium

Picture 19

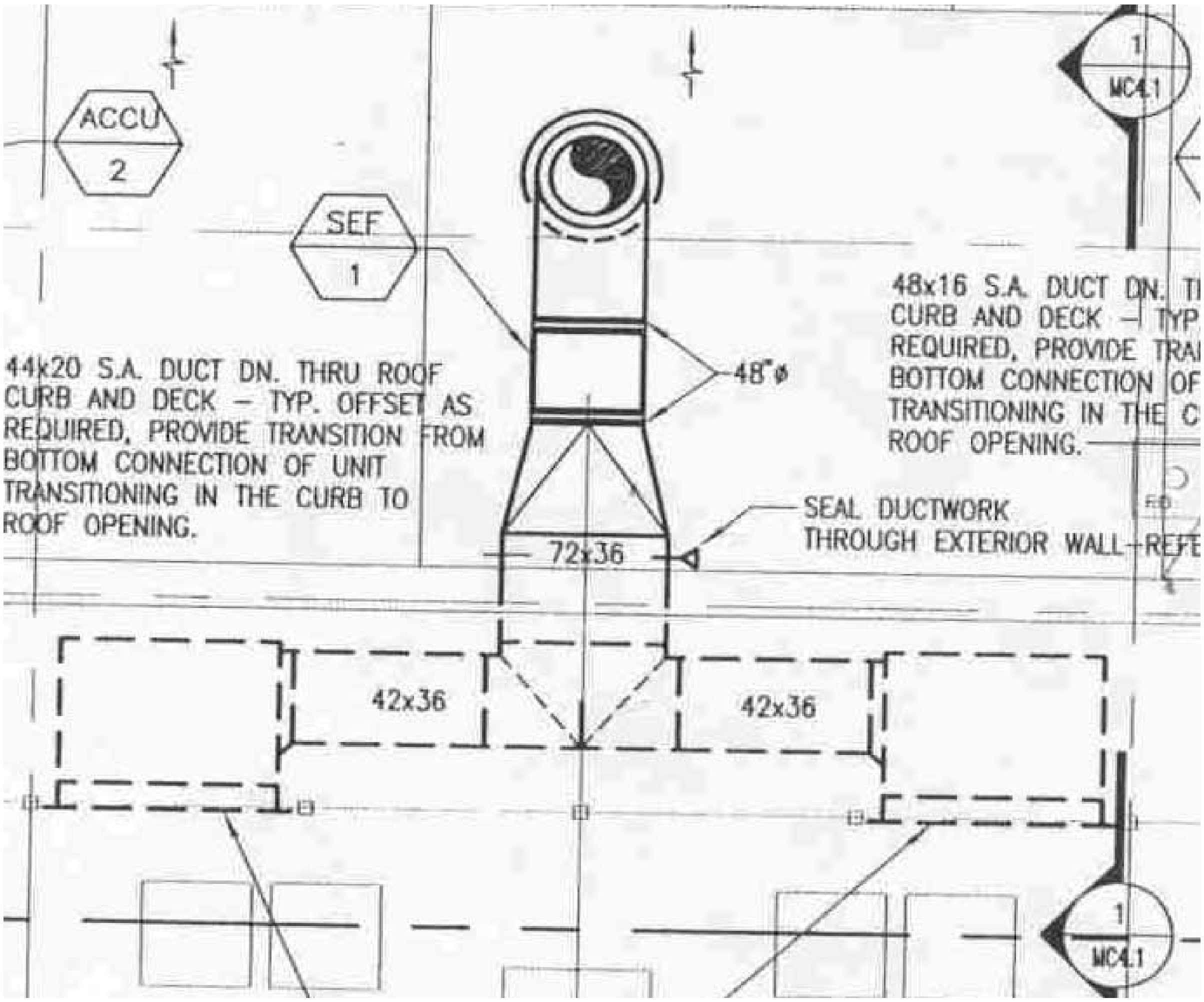
Gas-Fueled Cooking Devices in Kitchen

Picture 20

Tennis Balls on Legs of Chairs

Blueprint 1

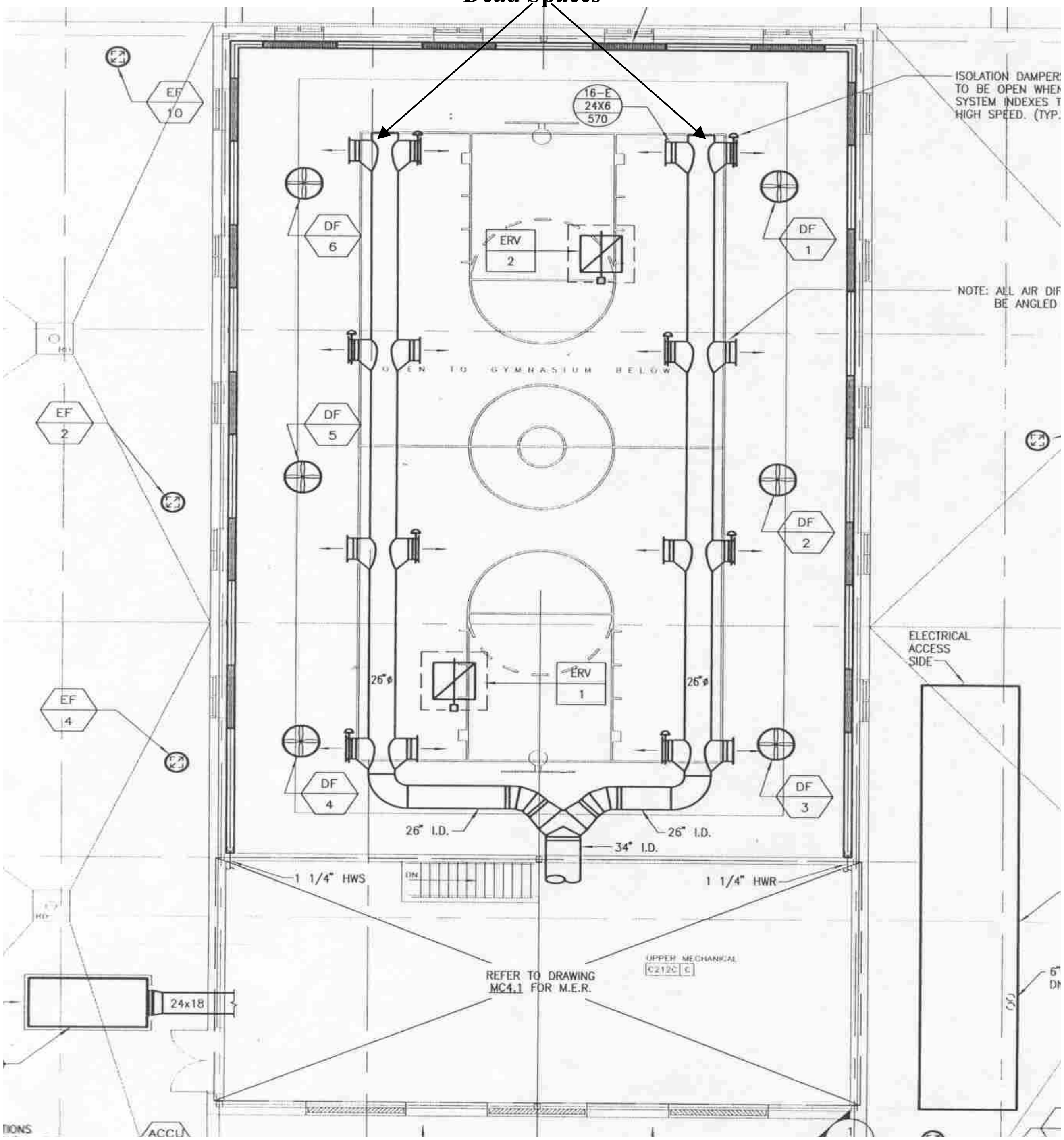
SES exhaust vent and stack do not have a backdraft damper on the top of the stack (Plans would list component as BDD)



Blueprint 2

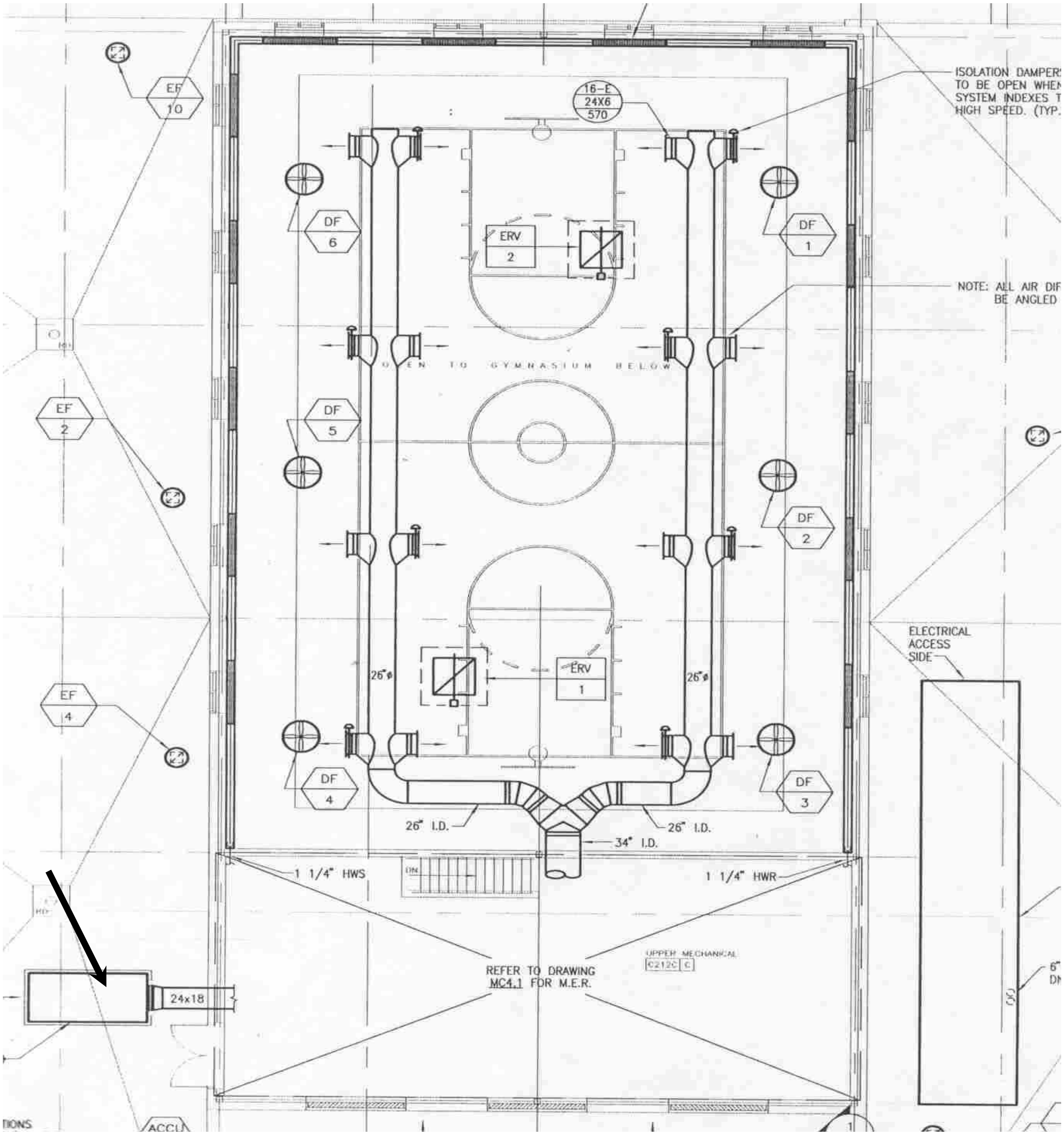
Gymnasium fresh air diffusers located several feet from the end of each circular duct, which creates a dead space to collect dust

Dead Spaces



Blueprint 3

Gas-fired make-up air vent for the kitchen (indicated by arrow)



Blueprint 4

Return Vent in Close Proximity to Boilers in Boiler Room (within Dotted Box)

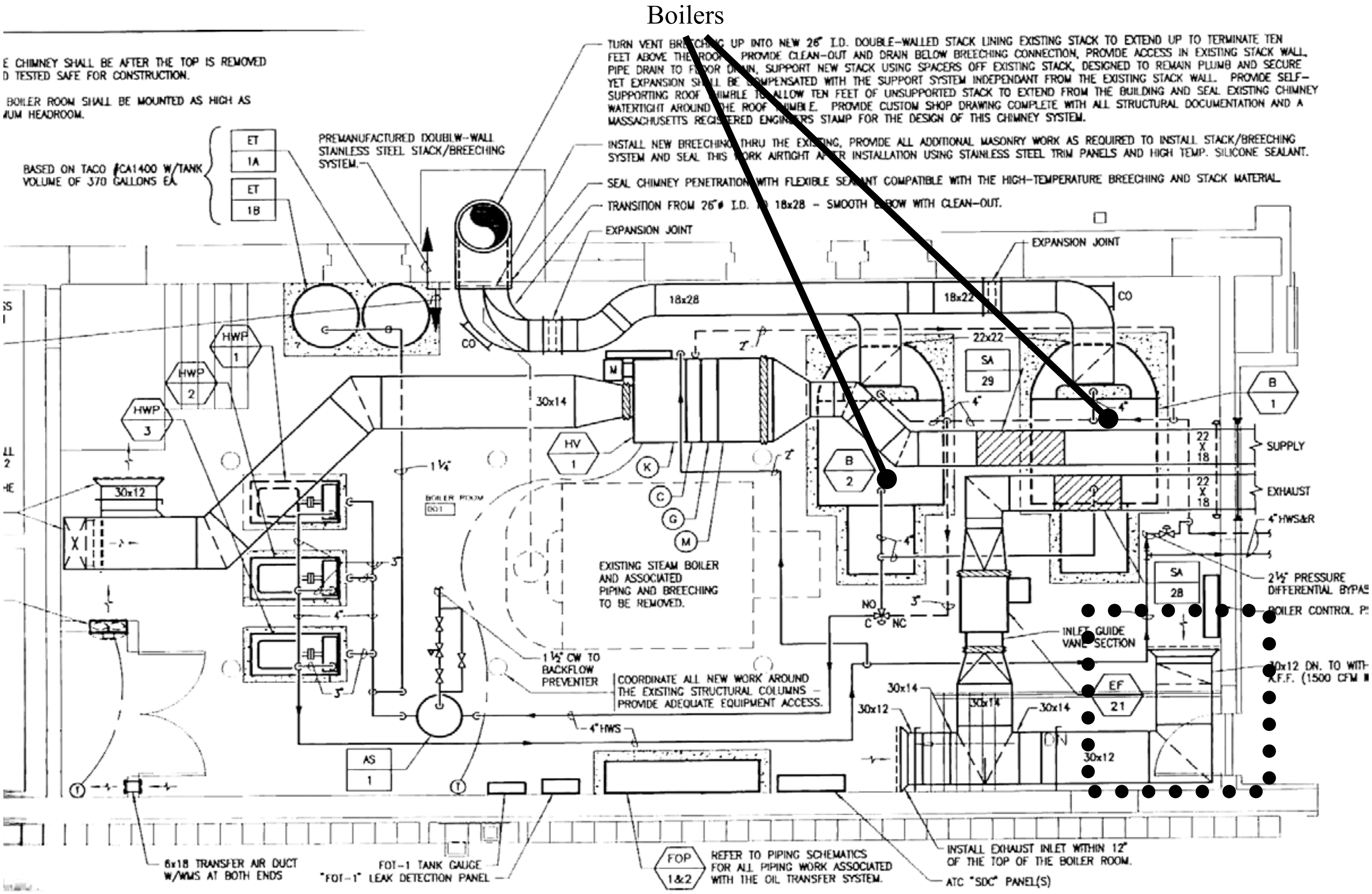


TABLE 1

Indoor Air Test Results – Springfield, Sumner Ave Elementary School July 26, 2002

Location	Carbon Dioxide *ppm	Carbon Monoxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Background	423	0	72	33					
Teacher's Room	796	0	70	51	2	Y	Y	Y	Lamination Machine, door open
A1	615	0	70	52	0	Y	Y	Y	
221	562	0	70	56	0	Y	Y	Y	Mold growth in FCU drip pan, door open
222	780	0	70	55	20	Y	Y	Y	Musty odors, door open
226	687	0	70	50	1	N	Y	Y	Tennis balls, ammonia-containing cleaner, door open
228	825	0	70	50	21	N	Y	Y	WD-sink, ammonia-containing cleaner, door open
231	831	0	70	56	21	Y	Y	Y	Supply off-blocked by desk, door open
232	915	2	70	56	25	Y	Y	Y	Supply off, door open
A200	680	2	71	53	22	Y	Y	Y	Window open, door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Springfield, Sumner Ave Elementary School **July 26, 2002**

Location	Carbon Dioxide *ppm	Carbon Monoxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
							Intake	Exhaust	
A2	630	2	71	53	22	Y	Y	Y	Door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%